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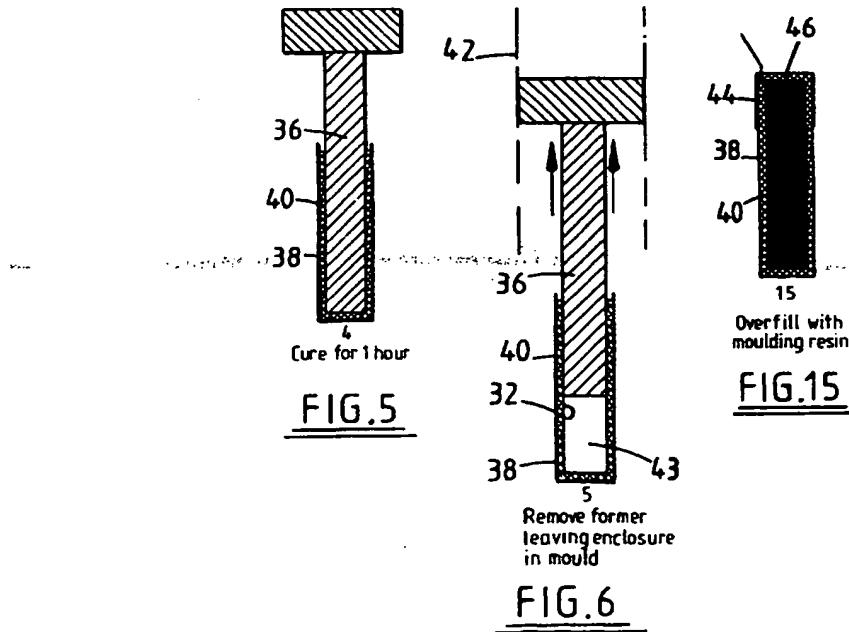
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(54) Encapsulation method

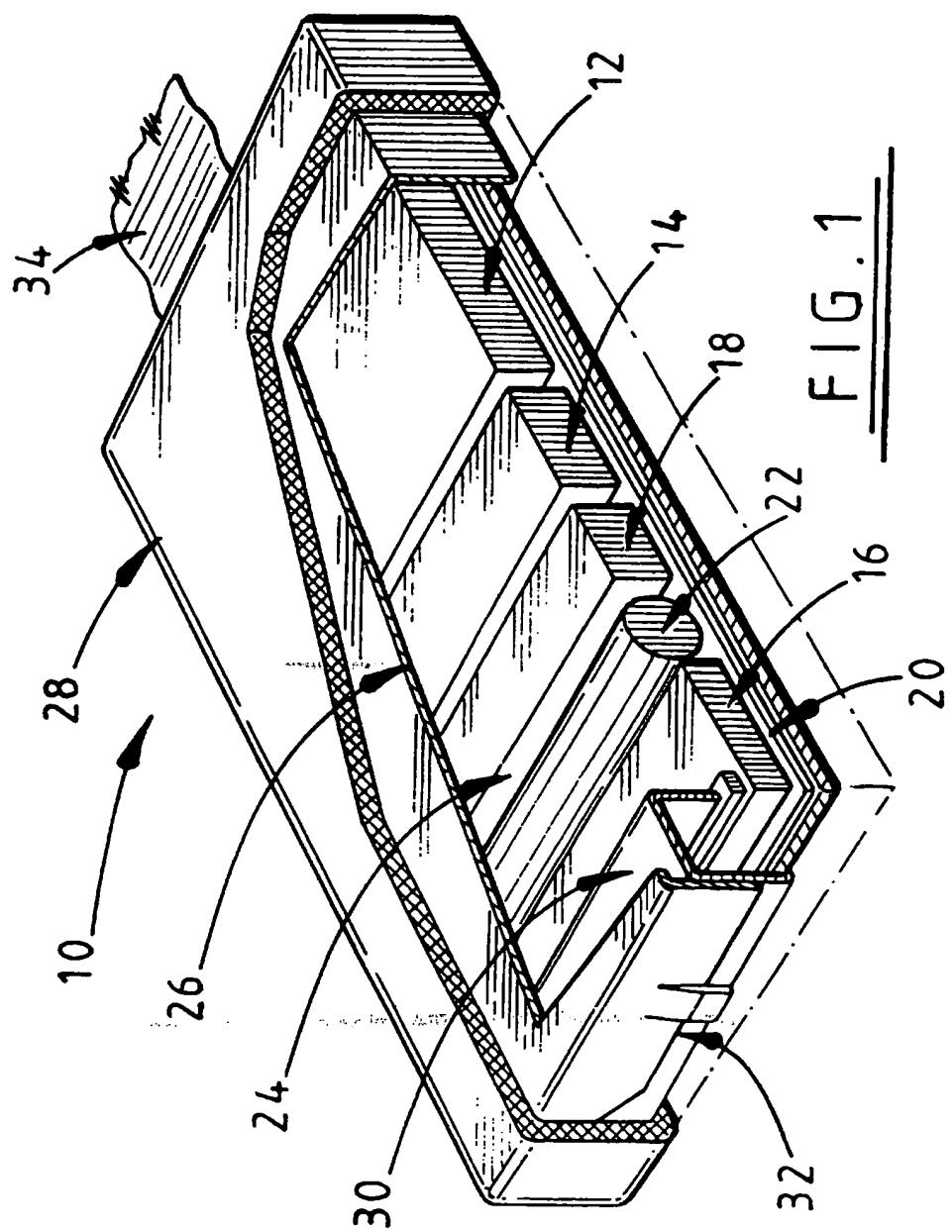
(57) A method of encapsulating an item comprises the steps: (a) providing an open mould (38); (b) locating a former (36) within the mould; (c) filling the space between the mould and the former with a first batch of settable material (40), the volume of material being selected such that portions of the mould and the former remain clear of the material; (d) setting the material such that the set material defines a partially enclosed volume (43), as occupied by the former; (e) locating an item (20) at least partially within this volume; (f) filling the mould with a second batch of settable material (46) to encapsulate the item; and (g) setting the further batch of material. The item to be encapsulated may serve as the former or a part thereof and thus remain in the mould throughout the encapsulation process. Alternatively, part or all of the former may be removed after the first batch of material has set.



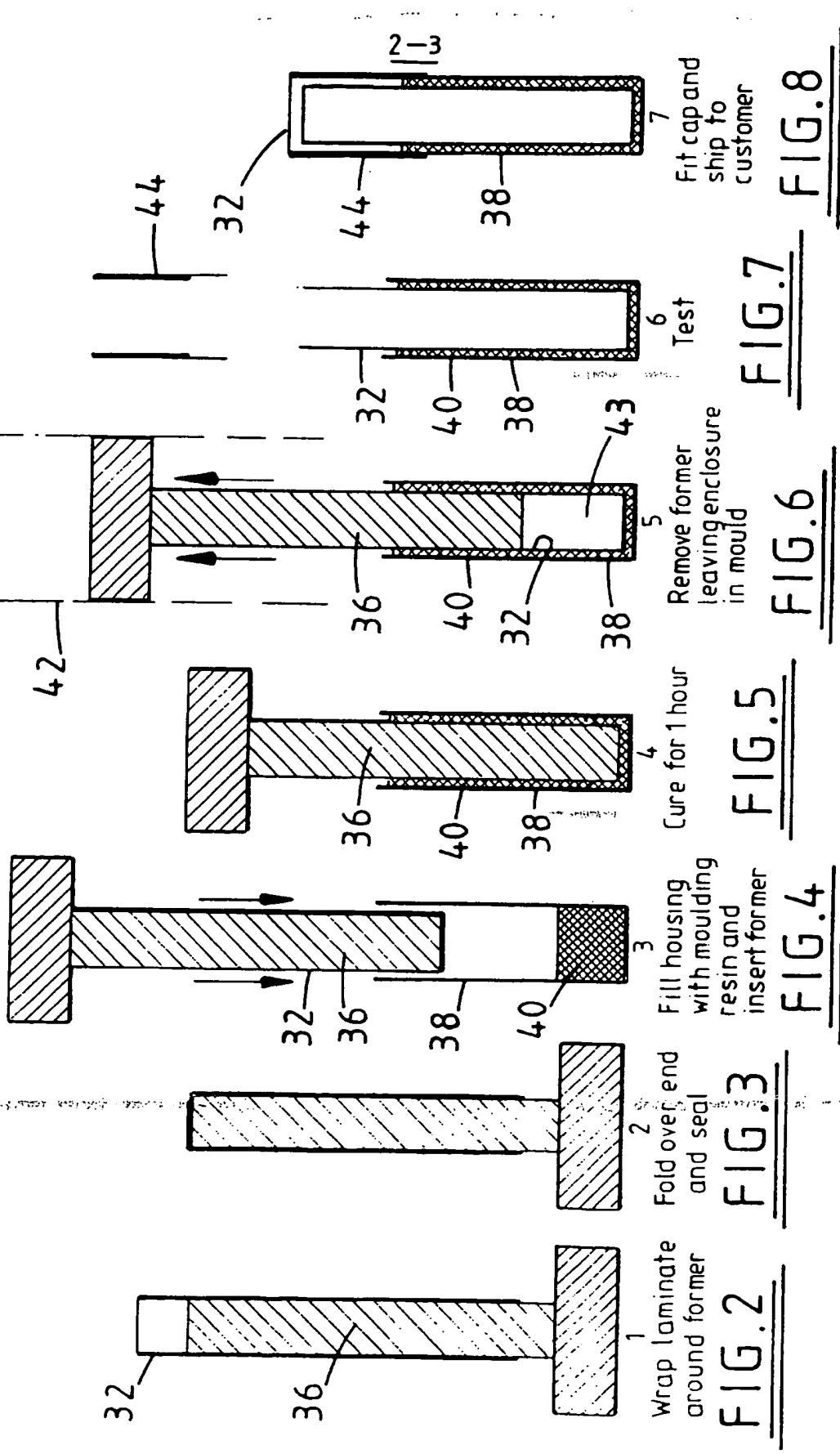
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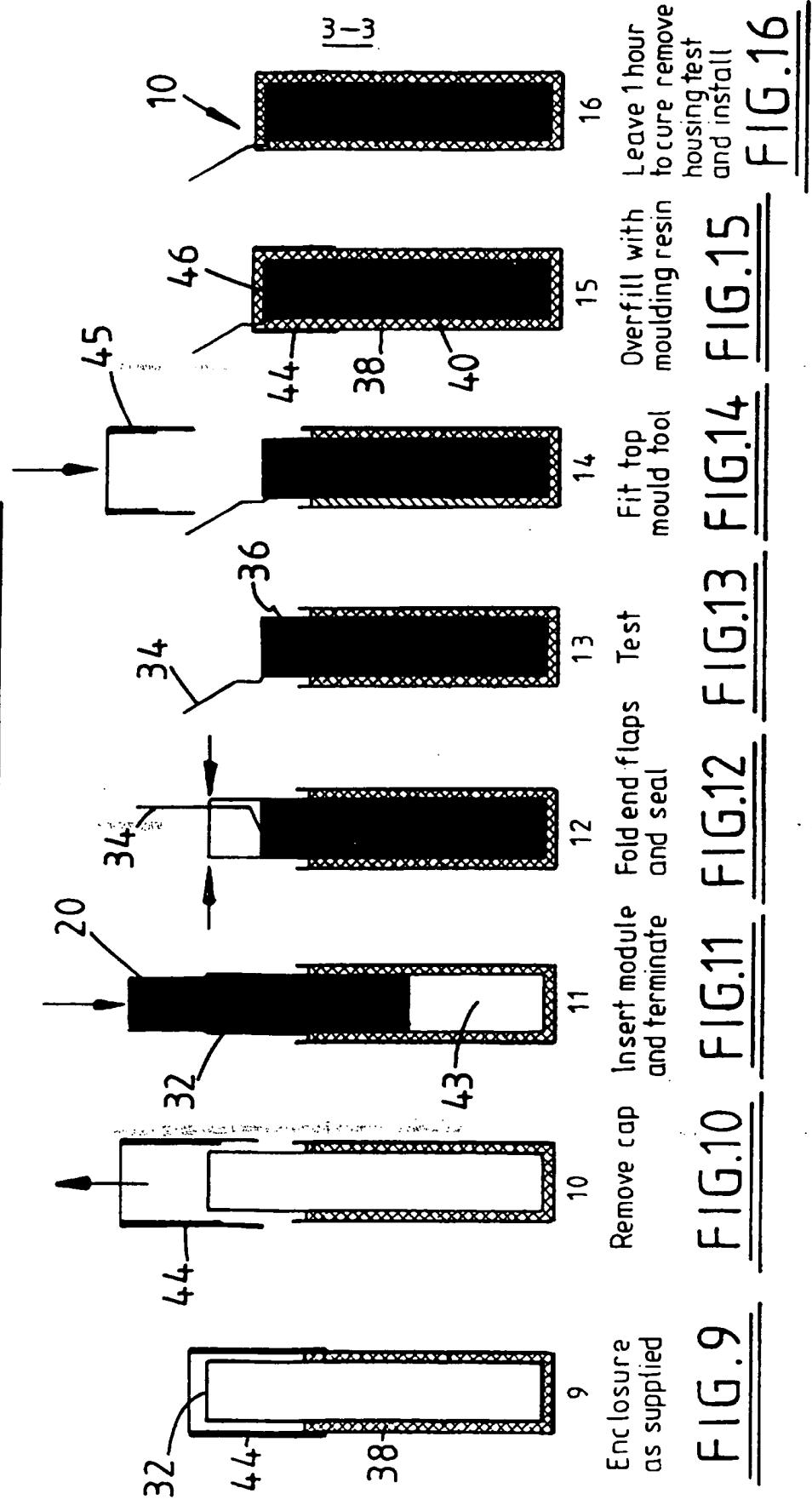
FIG. 1



Process Flow Chart For Molded Housing



Process Flow Chart For Moulded Housing



ENCAPSULATION METHOD

FIELD OF THE INVENTION

This method relates to a method of encapsulating an item.

SUMMARY OF THE INVENTION

The method of the present invention comprises the steps:

- (a) providing an open mould;
- (b) locating a former within the mould;
- (c) filling the space between the mould and the former with a first batch of settable material, wherein the volume of material is selected such that portions of the mould and the former remain clear of the material;
- (d) setting the material such that the set material defines a partially enclosed volume, as occupied by the former;
- (e) locating an item at least partially within said volume;
- (f) filling the mould with a second batch of settable material to encapsulate the item; and
- (g) setting the further batch of material.

The item to be encapsulated may also serve as the former or a part thereof and thus remain in the mould throughout the encapsulation process. Alternatively, part or all of the former may be removed after the first batch

of material has set.

The method of the invention allows items to be encapsulated within an enclosure without requiring the use of "standoffs": the former may be mounted externally of the mould when initially positioned within the open mould.

The present invention also allows an encapsulation process to be carried out in two stages, and thus at two separate locations if desired. This may be useful in forming a tamper respondent enclosure, such as described in our International Patent Application No. PCT/GB94/00464, the disclosure of which is incorporated herein by reference. Where, for example, a printed circuit board (PCB) carrying sensitive material, for example, details of interbank transactions, is to be encapsulated prior to shipping between two remote locations initial steps (a) to (d) may be carried out by the manufacturer of the enclosure who then supplies the part-finished enclosure to the customer. The PCB containing the sensitive material may then be encapsulated within the enclosure by the customer, following the relatively simple and straightforward steps (e) to (g), which requires little or no specialised equipment or skill. In this way the PCBs may be retained within the customer's control until the boards are fully encapsulated and ready for shipping.

The invention may also be used by manufacturers of equipment in which a part or component is to be encapsulated, for example: a computer terminal for use by a bank teller may have a memory circuit to which access is

to be restricted. The equipment manufacturers may be supplied with part-formed enclosures which are then used to encapsulate components and parts, such as memory circuits, prior to or during assembly of a piece of equipment.

The invention has particular application in the manufacture of tamper respondent enclosures as described in the abovementioned International Patent Application No. PCT/GB94/00464, which may incorporate various ones of the features disclosed in our earlier Patent Application Nos. GB 2 220 513 A, GB 2 258 075 A, GB 2 256 956 A, GB 2 256 957 A, GB 2 256 958 A and GB 2 270 785 A, the disclosures of which are incorporated herein by reference. The tamper respondent enclosure described in the International Application incorporates a tamper respondent laminate which is wrapped around an item to be protected, which wrapped item is then "potted" in a suitable settable material. Utilising the present invention, the tamper respondent laminate may be partially wrapped around the former such that once the first batch of material has set, and adhered to the outer surface of the laminate, the former may be removed leaving the laminate to define the walls of the partially-enclosed volume. An item to be protected is then placed in the volume and the portions of laminate extending from the set material folded over the end of the item and adhered in place. The second batch of settable material is then added to the mould to cover the exposed laminate, and on setting of the second batch the laminate-wrapped item is fully encapsulated.

Preferably, the mould is in at least two parts, and may comprise a principal mould and a mould extension. Preferably, the volume of the first batch of material is selected to partially fill the principal mould such that the line where the first batch of material joins the second batch of material is not visible in the finished product.

The inner surface of the mould may be configured to produce a trade mark, tamper evident pattern, logo and the like on the enclosure surface.

The encapsulating material may be selected from any suitable settable material, such as the cold pour polyurethane system disclosed in the above mentioned International Application.

The mould may be of any suitable form and material. Conveniently, the mould is formed of sheeting which may be folded to define a suitable mould shape. Once the enclosure has been formed the sheet material may be unfolded to release the set enclosure. The mould forming sheet may then be reused, recycled or discarded.

BRIEF DESCRIPTION OF THE DRAWINGS

This and other aspects of the present invention will now be described, by way of example, with reference to the accompany drawings, in which:

Figure 1 is a perspective part cut away view of a tamper respondent enclosure formed in accordance with an embodiment of the present invention; and

Figures 2 to 16 illustrate, somewhat schematically,

and in section, steps involved in forming the enclosure of Figure 1, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Reference is first made to Figure 1 of the drawings, which illustrates a tamper respondent enclosure 10 containing security sensitive information within an encryption module 12. Access to the information stored in the module 12 requires use of a variable key, the nature of the key required being stored within the memory 14. The enclosure 10 is arranged to detect attempts to tamper with or penetrate the enclosure and accordingly contains an enclosure monitor 16 which, if tampering is detected, activates an erase circuit 18 to erase the information stored in the memory 14 and encryption module 12. These components are mounted on and interconnected by a printed circuit board 20, power being provided by a single battery 22.

The walls of the enclosure comprise two primary components: inner enclosure 26 in the form of a folded tamper respondent laminate 32; and an outer enclosure in the form of a moulding 28, formed in accordance with an embodiment of the present invention.

As more fully described in International Patent Application No. PCT/GB94/00464, the tamper respondent laminate 32 includes various detection layers which are monitored, via a ribbon cable 30, by the enclosure monitor 16.

An input/output cable 34 extends through the moulding 28 and inner enclosure 26 and is utilised to activate and disable the enclosure monitor 16 to permit authorised access to the module 12.

The method of forming the enclosure 10, and in particular forming the moulding 28, will now be described with reference to the remaining Figures. The steps illustrated in Figures 2 to 8 would typically be carried out by the enclosure manufacturer, while the steps illustrated in Figures 9 to 16 would be carried out by a customer who wish to utilise the enclosure.

The tamper respondent laminate 32 is initially provided in planer form and is wrapped around a rectangular former 36 (Figure 2). The lower free end of the laminate 32 is then folded over the end of the former 36, in a similar manner to a paper wrapping on a parcel, and secured in place using suitable adhesive (Figure 3). A principal mould in the form of a housing 38 is provided and is filled with a predetermined volume of moulding resin 40. The laminate-wrapped former 36 is located within the housing 38 such that the resin occupies the space between the laminate 32 and the housing 38 (Figure 5). Guides or bearings 42 may be provided for guiding the former 36 into the housing 38 and for ensuring accurate location of the former 36 in the housing 38. The former 36 is left in the housing 38 until the resin 40 has cured. The former 36 is then removed from the housing 38, leaving the laminate 32, which is now firmly adhered to the cured resin 40 within the

housing 38 and defining a partially enclosed volume 43. The laminate 32 may then be subject to testing to ensure that no damage has occurred to the tamper respondent circuits.

It will be noted from Figures 5 that the volume of moulding resin 40 provided is selected such that the walls of the housing 38 extend above the level of the resin 40 and a portion of laminate 32 extends above the resin 40.

Prior to shipping to the customer the laminate 32 is folded to define an enclosure and a cap 44 is fitted to the housing 38 to protect the exposed portion of laminate 32.

On receiving the enclosure the customer removes the cap 44 (Figure 10) and unfolds the laminate 32 to allow the component carrying board 20 to be located within the volume 43 defined by the laminate 32. The ribbon cable 30 is connected to the enclosure monitor 16. The laminate 32 is then refolded (Figure 12), the input/output ribbon cable 34 being arranged to pass through the folded laminate in a serpentine manner. The folded portions of the laminate are secured in place with adhesive, and the integrity of the inner enclosure 26, as defined by the laminate 32, tested.

The customer then fits a mould extension 45 to the upper end of the housing 38 (Figure 14) and fills the extension 45 and the upper end of the housing 38 with a second batch of moulding resin 46 (Figure 15). After the resin 46 has cured, the extension 45 and housing 38 are removed and the finished enclosure 10 subject to final testing.

The board 20 is now securely encapsulated within the inner enclosure 26 and the moulding 28 and it has been found that the join between the first and second batches of resin 40, 46 is mechanically and chemically complete, and is not visible to the eye.

It will be clear to those of skill in the art that the abovedescribed embodiment is merely exemplary of the present invention and that the invention has application in many other forms of moulding process. The "two-stage" moulding process may be usefully utilised where it is desired to accurately locate an item within encapsulating material; the item may be accurately located by external supports relative to the housing 38 while the first batch of moulding resin is curing. Thus, the requirement to provide "stand-offs" is obviated.

CLAIMS

1. A method of encapsulating an item comprising the steps:

- (a) providing an open mould;
- (b) locating a former within the mould;
- (c) filling the space between the mould and the former with a first batch of settable material, wherein the volume of material is selected such that portions of the mould and the former remain clear of the material;
- (d) setting the material such that the set material defines a partially enclosed volume, as occupied by the former;
- (e) locating an item at least partially within said volume;
- (f) filling the mould with a second batch of settable material to encapsulate the item; and
- (g) setting the further batch of material.

2. The method of claim 1 wherein the item to be encapsulated serves as the former or a part thereof and remains in the mould throughout the encapsulating process.

3. The method of claim 1 wherein part or all of the former is removed after the first batch of material has set.

4. The method of claim 1, 2 or 3 wherein the former is

4. The method of claim 1, 2 or 3 wherein the former is mounted externally of the mould when initially positioned within the open mould.
5. The method of any of claims 1 to 4 wherein the mould is in at least two parts.
6. The method of claim 5 wherein the mould comprises a principal mould and a mould extension, and the volume of the first batch of material is selected to partially fill the principal mould such that the line where the first batch of material joins the second batch of material is not visible in the finished enclosure.
7. The method of any of the preceding claims wherein the inner surface of the mould is configured to produce a trade mark, tamper evident pattern, logo and the like on the enclosure surface.
8. The method of any of the preceding claims wherein the encapsulating material is a cold pour polyurethane system.
9. The method of any of the preceding claims wherein the mould is formed of sheeting folded to define a suitable mould shape.
10. A method of producing a tamper respondent enclosure comprising the steps:

- (a) providing an open mould;
- (b) locating a former wrapped with a tamper respondent enclosure within the mould;
- (c) filling the space between the mould and the wrapped former with a first batch of settable material, wherein the volume of material is selected such that portions of the mould and the wrapped former remain clear of the material;
- (d) setting the material such that the set material defines a partially enclosed volume defined by the tamper respondent laminate;
- (e) removing the former from the set material;
- (f) locating an item within the volume defined by the tamper respondent laminate;
- (g) wrapping the exposed portion of the tamper respondent laminate around the item to form an inner enclosure;
- (h) filling the mould with a second batch of settable material to encapsulate the inner enclosure; and
- (i) setting a further batch of material.

11. The encapsulation method substantially as described herein and as illustrated in the accompanying drawings.



The
Patent
Office

Application No: GB 9517569.1
Claims searched: 1-11

Examiner: J P Leighton
Date of search: 12 December 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.N): B5A(AA1, AB10, AB12, AB13, AB14, AB18, AB19)

Int CI (Ed.6): B29C(39/10, 45/14); E05G(1/00); G08B(13/00, 13/12)

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0526066 A1 W L Gore & Associates	
A	WO 94/20935 A1 "	
A	WO 94/07221 A1 "	
A	AU 0598272 A Standard Telephones & Cables Pty. Limited	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.